White Paper on
Observations of Air Pollution from Space and their Use for Human Benefit

The nation and the world face new opportunities to make environmental decisions based on data that have never before been available. Changes in the chemistry of the atmosphere, especially in regard to air quality and human health, are due to the natural variability of a dynamic planet, and the intersection of forcings from industrialized and rapidly industrializing economies, including transportation, manufacturing, and concentrated urban environments. The consequences of these profound human-driven changes to the global environment require decision makers to develop creative response and adaptation strategies. Science develops and communicates the essential knowledge to inform debate, and ultimately decisions, on how to respond to the changing effects of human activity on the one planet that we know supports life.

Air Quality and Observations from Space

Human activity has altered the chemistry of the lower atmosphere affecting the radiative balance, dynamics, and chemistry of the atmosphere. On a regional scale, the US Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards for Criteria Pollutants (ozone, carbon monoxide, nitrogen oxides, sulfur dioxide, mercury, and aerosols; Clean Air Act 1970 and Amendments), and provides surface monitoring in urban areas. In the recent past, NASA's Applied Science program has supported the technical evaluation of space based observations of criteria and related pollutants in partnership with US EPA (NASA National Applications Program Plan and Agency Deliverables). This work has brought a rich new resource of surface data to the scientific community, and the previously unattainable view of national air pollution distributions to the air quality assessment and management communities. Satellite products from NASA's newest Aura mission are being evaluated by the air quality community, and satellite data are used in daily efforts to predict, manage, and mitigate the harmful effects of air pollution. Such satellite products introduce a regional scope with coarse spatial resolution to what had previously been a sparse sample of point values, but present satellite observations remain inadequate in the temporal dimension. Relating air pollution to primary drivers is possible only with dawn-to-dusk time resolution throughout the day. For example, intensity of sunlight drives photochemistry, and rush hour traffic drives intense concentrations of select pollutants. This White Paper describes the important new focus of time-resolved tropospheric chemistry.

Time-resolved Tropospheric Chemistry Mission

The measurement physics and retrieval algorithms for criteria air pollutants have been demonstrated with limited temporal and spatial resolution from low Earth orbit by instruments such as MAPS, MOPITT, MODIS, TOMS, SCIAMACHY, and GOME. Recent studies and proposals (Blue Horizons, GeoTRACE) indicate that distributions of the criteria air pollutants can be sampled across continental-scale regions with ~5 km horizontal spatial resolution every hour from geostationary orbit (geo) using well-validated physics, because of the enhanced integration time provided by the stationary platform. Geo is approximately 50 times farther from Earth than the Aura platform. Geo orbit is the mechanism to address time resolution from space. If instruments are confined to low or middle Earth orbits, the time sampling for continental-scale domains is at best once per day from a single platform. Swarms (multiple platforms) have been studied to assess the number of systems required to improved temporal sampling over a large spatial domain; the complexity and cost of the requisite number of platforms exceeds the cost of a single system in geostationary orbit. Consequently, we suggest that the appropriate implementation of a highly utilizable time-resolved tropospheric chemistry mission requires the use of a geo platform. Operation from geo has been fully demonstrated by meteorological and commercial communications satellites.

Science Justification

Aerosol and gaseous pollution from human activities and large-scale wildfires rise above the boundary layer and can travel great distances, sometimes returning to the surface at sites geographically and jurisdictionally distant from the sources, due to the effects of weather and chemical processes. This complex behavior of trace atmospheric constituents that affect human health and ecosystems can be fully understood only with an integrated observing system that comprises process studies, source/point data, global observations, and time-resolved observations. The pieces of such an integrated observing system for criteria pollutants are substantially in place, except for the time-resolved observations, the last piece in the puzzle. Consequently, the financial investment in a time-resolved tropospheric chemistry mission completes the system and yields enormous scientific return.

In conjunction with the International Earth Observation Summit of July 2003, the Integrated Global Observing Strategy (IGOS) Partnership issued the Integrated Global Atmospheric Chemistry Observations (IGACO) Theme Report outlining the strategy for tropospheric chemistry measurements with time and space resolution to support forecasting, assessment, and management of air quality (i.e., observations from geostationary orbit). IGOS operates under the United Nations. The World Meteorological Organization calls for the IGACO system to be operational by 2013.

Public Benefit

In 2001, more than 133 million Americans (out of a total population of 281 million) lived in counties where monitored air quality was unhealthy at times because of high levels of at least one air pollutant controlled under the National Ambient Air Quality Standards. In 2004, US EPA presented requirements for observations of criteria pollutants at the GOES-R users meeting, emphasizing their need for time-resolved observations. NOAA signed an MOA with US EPA in 2004 governing the integration of EPA's tropospheric chemistry model into national air quality forecast guidance to be delivered by NOAA in the next decade. NOAA, NASA, and US EPA are using existing satellite observations of trace constituents to interpret pollution events and assist in the first efforts to predict next-day air quality, based on the near-real time data availability of some satellite observations via direct broadcast and other near-real-time data delivery concepts. Atmospheric chemistry models assist in these efforts to forecast and interpret trace gas distributions, but models require testing, using data obtained on time and space scales similar to model steps in order to demonstrate veracity of model results. Time-resolved observations will address this model validation need. Once verified, the models can support international policy formulation and compliance.